

Appl. No. 10/090,761
Amendment dated June 24, 2004
Reply to Office Action of March 24, 2004

REMARKS

Claims 1-20 and 22 are pending in this application. For purposes of expedition, claim 21 has been canceled without prejudice or disclaimer. Claims 1-4, 10, 13, 14, 16, 19 and 20 have been amended in several particulars for purposes of clarity and brevity while Claim 22 has been newly added to replace canceled claim 21 to alternatively define Applicants' disclosed invention and to assist the Examiner to expedite compact prosecution of the instant application.

Claims 2, 4, 12, 14 and 21 have been objected to because of informalities. As discussed, claim 21 has been canceled without prejudice or disclaimer. Claims 2, 4, 12 and 14 have been reviewed and revised in those instances kindly listed by the Examiner to overcome the objection.

Claims 1-2 have been rejected under 35 U.S.C. §102(e) as being anticipated by Ying et al., U.S. Patent No. 6,541,380. In support of this rejection, the Examiner asserts that Ying '380 discloses a plasma etching process for metal using a mask formed on a metal layer, and that this process comprises "etching a metal layer 116 of platinum (claimed hardly-etched material) formed on a substrate using a mask 118, the mask 118 having a sidewall angled at less than 90 degree with respect to the surface of the substrate 112 (col. 4, lines 18-20, col. 5, lines 5-6)." Actually, the cited col. 4, lines 18-20, and col. 5, lines 5-6 of Ying '380 simply refer to the specific type of metal or metal oxide layer 116 disposed on the substrate 112, as shown in FIG. 1A, and subsequently etched through apertures in the patterned masking layer 118, resulting in a structure shown in FIG. 1B. Ying '380 employs mixes gases of CO and C12 in order to suitable etch the metal or metal oxide layer 116.

Appl. No. 10/090,761
Amendment dated June 24, 2004
Reply to Office Action of March 24, 2004

In contrast to Ying '380, Applicants' base claim 1 specifically defines a plasma-based method of etching a film of hardly-etched material using said mask having a sidewall angled at 90 degrees or less with respect to the surface of the substrate. In other words, the sidewall of a hardly-etched material is etched so as to have a tapered angle as closer to 90 degrees as possible. This is because Applicants recognize for the first time that, when a mask is configured to be tapered in advance, the sidewall of a hardly-etched material, such as Pt, can be formed to have a tapered angle closer to 90 degrees and obtained using an equation (expression) representing the relation between a target tapered angle of a hardly-etched material and a tapered angle of a mask.

Again, the cited column 4, lines 18-20 and column 5, lines 5-6 of Ying '380 merely disclose that hardly-etched materials such as Pt are used as material to be etched by using plasma. However, Ying '380 does **not** disclose that the hardly-etched material is etched by using a mask having a sidewall with a tapered angle of 90 degrees or less.

The rule under 35 U.S.C. §102 is well settled that anticipation requires that each and every element of the claimed invention be disclosed in a single prior art reference. In re Paulsen, 30 F.3d 1475, 31 USPQ2d 1671 (Fed. Cir. 1994); In re Spada, 911 F.2d 705, 15 USPQ2d 1655 (Fed. Cir. 1990). Those elements must either be inherent or disclosed expressly and must be arranged as in the claim. Richardson v. Suzuki Motor Co., 868 F.2d 1226, 9 USPQ2d 1913 (Fed. Cir. 1989); Constant v. Advanced Micro-Devices, Inc., 848 F.2d 1560, 7 USPQ2d 1057 (Fed. Cir. 1988); Verdegall Bros., Inc. v. Union Oil Co., 814 F.2d 628, 2 USPQ2d 1051 (Fed. Cir. 1987). The corollary of that rule is that absence from the reference of

Appl. No. 10/090,761
Amendment dated June 24, 2004
Reply to Office Action of March 24, 2004

any claimed element negates anticipation. Kloster Speedsteel AB v. Crucible Inc., 793 F.2d 1565, 230 USPQ2d 81 (Fed. Cir. 1986).

The burden of establishing a basis for denying patentability of a claimed invention rests upon the Examiner. The limitations required by the claims cannot be ignored. See In re Wilson, 424 F.2d 1382, 165 USPQ 494 (CCPA 1970). All claim limitations, including those which are functional, must be considered. See In re Oelrich, 666 F.2d 578, 212 USPQ 323 (CCPA 1981). Hence, all words in a claim must be considered in deciding the patentability of that claim against the prior art. Each word in a claim must be given its proper meaning, as construed by a person skilled in the art. Where required to determine the scope of a recited term, the disclosure may be used. See In re Barr, 444 F.2d 588, 170 USPQ 330 (CCPA 1971).

In the present situation, Ying '380 fails to disclose and suggest key features of Applicants' claims 1-2. Therefore, Applicants respectfully request that the rejection of claims 1-2 be withdrawn.

Nevertheless, for purposes of expedition, base claim 1 has been amended to further define the equation (expression) representing the relation between a target tapered angle of a hardly-etched material and a tapered angle of a mask in order to ensure that a target tapered angle of the etched film is obtained. For example, base claim 1 defines,

"etching said film of hardly-etched material using said mask having a side wall which surface forms an angle of substantially θ with respect to a surface of said substrate, said θ being given by $\tan \Phi = (re-rd) / ((rd-re \times \cos \theta) \times \sin \theta)$ supporting that said Φ is a target tapered angle of said film of hardly-etched material after being etched, wherein re is an etching rate of said film of hardly-etched material and rd is a deposition rate of reaction product to said side wall."

Appl. No. 10/090,761
Amendment dated June 24, 2004
Reply to Office Action of March 24, 2004

Base claim 1, as amended, is clearly distinguishable over Ying '380 and should be placed in condition for allowance.

Claim 21 has been rejected under 35 U.S.C. §102(b) as being anticipated by Nagano et al., U.S. Patent No. 6,100,100 for reasons stated on page 3 of the Office Action (Paper No. 031804). As discussed, for purposes of expedition, claim 21 has been canceled without prejudice or disclaimer to render the rejection moot.

Claims 3-9 and 12 have been rejected under 35 U.S.C. §102(e) as being anticipated by Ying, U.S. Patent No. 6,541,380 for reasons stated on pages 3-4 of the Office Action (Paper No. 031804). As previously discussed, the cited col. 4, lines 18-20, and col. 5, lines 5-6 of Ying '380 simply refer to the specific type of metal or metal oxide layer 116 disposed on the substrate 112, as shown in FIG. 1A, and subsequently etched through apertures in the patterned masking layer 118, resulting in a structure shown in FIG. 1B. Ying '380 does **not** disclose that the hardly-etched materials is etched by using a mask having a sidewall with a tapered angle of 90 degrees or less, as alleged by the Examiner.

Nevertheless, base claims 3 and 4 have been amended to define the equation (expression) representing the relation between a target tapered angle of a hardly-etched material and a tapered angle of a mask in order to ensure that a target tapered angle of the etched film is obtained. For example, base claim 3 has been amended to define,

"etching said film of hardly-etched material using said mask having a side wall formed with a taper angle of substantially θ with respect to a surface of said substrate, to form an etched film with a taper angle with respect to the surface of said substrate equal to or larger than the taper angle of said mask, said θ being given by $\tan \Phi = (r_e - r_d) / ((r_d - r_e \cos \theta) \times \sin \theta)$, wherein said Φ is a target tapered angle of said film of hardly-etched material after being etched, r_e is an

Appl. No. 10/090,761
Amendment dated June 24, 2004
Reply to Office Action of March 24, 2004

etching rate of said film of hardly-etched material and rd is a deposition rate of reaction product to said side wall."

Likewise, base claim 4 has been amended to define,

forming said mask such that a side wall of said mask has a taper angle of substantially θ with respect to the surface of said substrate, said θ being given by $\tan \Phi = (re-rd) / ((rd-re \times \cos\theta) \times \sin\theta)$; and etching said film of hardly-etched material using said mask, wherein said Φ is a target tapered angle of said film of hardly-etched material after being etched, re is an etching rate of said film of hardly-etched material and rd is a deposition rate of reaction product to said side wall.

These features of Applicants' base claims 3 and 4 are not disclosed or suggested anywhere in Ying '380 or any other prior art of record. As a result, Applicants believe that the rejection of Applicants' claims 3-9 and 12 be withdrawn, and that claims 3-9 and 12 be placed in condition for allowance.

Claims 16-18 have been rejected under 35 U.S.C. §102(e) as being anticipated by Ying, U.S. Patent No. 6,541,380 for reasons stated on pages 4-5 of the Office Action (Paper No. 031804). Again, Ying '380 does not disclose that the hardly-etched materials is etched by using a mask having a sidewall with a tapered angle of 90 degrees or less, as alleged by the Examiner. Nevertheless, the Examiner asserts that since Ying '380 describes that some deposition is adhered to an inner surface of a reactor of an etching apparatus as a result of an etching process, the features of Applicants' claims 16-18 must be known. However, as described on page 35, lines 1-16 of Applicants' specification, the feature of Applicants' claim 16 resides in that, by reducing the impedance of the load (heater) 115 to reduce a current flowing into the electrostatically coupled antenna 118, a less amount of deposition material is deposited on the side walls of the mask and etched

Appl. No. 10/090,761
Amendment dated June 24, 2004
Reply to Office Action of March 24, 2004

material, so that the etched material can be formed with the side wall close to the perpendicular, even using a mask having a side wall angled substantially at 90 degrees.

Therefore, in the interest of expedition, Applicants' base claim 16 has been amended to define an etching method for attaching a reaction product on an inner wall of a vacuum chamber of an etching apparatus which is arranged in a manner that a high frequency current is supplied to a coil provided on an outer peripheral portion of said vacuum chamber to generate plasma within said vacuum chamber, etching gas is introduced into said vacuum chamber through a gas introducing port and exhausted from an exhauster, and an electrostatically coupled antenna grounded through a load is provided on the outer peripheral portion of said vacuum chamber, comprising the step of:

"continuously attaching said reaction product to the inner wall of said vacuum chamber until at least one wafer has been processed in a state that an impedance of said load is reduced to make an amount of current flowing into said electrostatically coupled antenna small, such that an etched material formed on a substrate within said vacuum chamber has a side wall angled substantially at 90 degrees with respect to the surface of said substrate."

Base claim 16, as amended, should render the rejection moot. Therefore, Applicants respectfully request that the rejection of Applicants' claims 16-18 be withdrawn.

Claims 19-20 have been rejected under 35 U.S.C. §102(e) as being anticipated by Garriga, U.S. Patent No. 6,451,118 for reasons stated on page 5 of the Office Action (Paper No. 031804). In support of this rejection, the Examiner asserts that Garriga '118 discloses the use of an etching chamber, an ashing

Appl. No. 10/090,781
Amendment dated June 24, 2004
Reply to Office Action of March 24, 2004

chamber and a rinsing chamber to realize the sequential proceedings of the etching processing, post-processing, etching processing and post-processing.

In contrast to the Garriga '118 and the Examiner's assessment of Garriga '118, Applicants' claims 19-20 define features, as shown in Figs. 15A, 15B, 16 and 17, in that the deposition material adhered on a side wall of the etched material is removed by the post-processing after the etching processing and then the etching processing is executed thereafter, whereby the side wall of the etched material can be formed to have a tapered angle much closer to 90 degrees as compared with the case of collectively performing the etching process.

For purposes of expedition, claims 19 and 20 have been amended to clearly distinguish over Garriga '118 in order to render the rejection moot. For example, Applicants' base claim 19 has been amended to define a method of etching a material under processing using a semiconductor device fabricating apparatus comprising a wafer carrier, a plurality of processing chambers and a plurality of post-processing chambers connected to said wafer carrier, a plurality of lock chambers, and an atmosphere carrier located adjacent to said lock chambers, wherein said atmosphere carrier can be connected to said plurality of lock chambers, and a wafer cassette adjacent to said atmosphere carrier, said method comprising the steps of:

"etching the material under processing in one of said plurality of processing chambers;

post-processing the material under processing in one of said plurality of post-processing chambers thereby to remove deposition material from a side wall of the material under processing;

etching the material in one of said plurality of processing chambers; and

post-processing the material under processing in one of said plurality of post-processing chambers."

Appl. No. 10/090,761
Amendment dated June 24, 2004
Reply to Office Action of March 24, 2004

Likewise, Applicants' base claim 20 has been amended to define a method of etching a material under processing using a semiconductor device fabricating apparatus comprising a wafer carrier, a plurality of processing chambers connected to said wafer carrier, a plurality of lock chambers, and an atmosphere carrier located adjacent to said lock chambers, wherein said atmosphere carrier can be connected to said plurality of lock chambers, a post-processing chamber adjacent to said atmosphere carrier, and a wafer cassette adjacent to said atmosphere carrier, said method comprising the steps of:

"etching the material under processing in one of said plurality of processing chambers;
post-processing the material under processing in said post-processing chamber thereby to remove deposition material from a side wall of the material under processing;
etching the material in one of said plurality of processing chambers; and
post-processing the material under processing in said post-processing chamber."

Base claims 19-20, as amended, should render the rejection moot.
Therefore, Applicants respectfully request that the rejection of Applicants' claims 19-20 be withdrawn.

Dependent claims 10-11 have been rejected under 35 U.S.C. §103(a) as being unpatentable over Ying et al., U.S. Patent No. 6,541,380 in view of Nagano et al., U.S. Patent No. 6,100,100 for reasons stated on page 6 of the Office Action (Paper No. 031804). In support of this rejection, the Examiner further asserts that Nagano '100 discloses a method of manufacturing a capacitor comprising the step of washing the mask while etching the mask and subsequently etching again the mask, such that Applicants' claims 10-11 would be obvious over Ying '380 in view of Nagano '100.

Appl. No. 10/090,761
Amendment dated June 24, 2004
Reply to Office Action of March 24, 2004

However, Nagano '100 intends to remove the deposition material adhered to the sidewall of a mask after etching the material to be etched.

In contrast to Ying '380 and Nagano '100, Applicants' claims 10-11 define features, as shown in Figs. 12 and 13, in that after dry-etching the mask, the mask is not subjected to the washing processing but subjected to the wet-etching thereby to control the tapered angle or configuration of the mask, as shown in Fig. 12C or 13C.

For purposes of expedition, claims 10 and 11 have been amended to clarify the distinction between dry etching and wet etching in order to render the rejection moot.

Claims 13-14 have been rejected under 35 U.S.C. §103(a) as being unpatentable over Nagano et al., U.S. Patent No. 6,100,100 in view Arao et al., U.S. Patent No. 6,596,571 for reasons stated on pages 6-7 of the Office Action (Paper No. 031804). In support of this rejection, the Examiner further asserts that Nagano '100 discloses a method of removing the deposition material adhered to the sidewall of a mask after etching the material to be etched, and that Arao '571, as a secondary reference, discloses the etching process after the washing process, such that Applicants' claims 13-14 would be obvious over Nagano '100 in view of Arao '571.

However, Applicants' claims 13-14 define features, as shown in FIGs. 14-17, in that the material to be etched is washed on the way of the etching process and thereafter etched again thereby to increase the tapered angle of the side wall of the material to be etched. To be more concrete, for example in the processes shown in FIGs. 14A-14F, the etched material 50a with a tapered angle Φ 1 is obtained by the first etching process (Fig. 14C), then the second etching process is performed by using the etched material 50a as a tapered mask thereby to make the tapered angle

Appl. No. 10/090,781
Amendment dated June 24, 2004
Reply to Office Action of March 24, 2004

Φ 2 of an etched material 50b further closer to 90 degrees (Fig. 14D). Such a phenomenon was discovered for the first time by Applicants based on the aforesaid expression $\tan \Phi = (re-rd) / ((rd-re \times \cos \theta) \times \sin \theta)$.

For purposes of expedition, Applicants' base claim 13 has been amended to define a method of fabricating a semiconductor device using at least one layer of hardly-etched material formed on a substrate, and a mask formed on said hardly-etched film, said method comprising the steps of:

performing a first etching of said layer of hardly-etched material by a predetermined amount using said mask, during which a first part of said layer exposed for the first time by said first etching is formed with a first taper angle θ with respect to a surface of said substrate; washing out an etching product in the middle of the etching; and

performing a second etching of said layer of hardly-etched material by a remaining amount using said mask, during which a second part of said layer exposed for the first time by said second etching is formed with a second taper angle of substantially Φ with respect to the surface of said substrate given by $\tan \Phi = (re-rd) / ((rd-re \times \cos \theta) \times \sin \theta)$, wherein the second taper angle is larger than the first taper angle, and wherein re is an etching rate of said film of hardly-etched material and rd is a deposition rate of reaction product to said side wall.

These features of Applicants' base claim 13 are not disclosed or suggested anywhere in Nagano '100 or Arao '571. As a result, Applicants believe that the rejection of Applicants' claims 13-14 be withdrawn, and that claims 13-14 be placed in condition for allowance.

Lastly, claims 13 and 15 have been rejected under 35 U.S.C. §103(a) as being unpatentable over Yokoyama et al., U.S. Patent No. 5,515,984 in view of Nagano et al., U.S. Patent No. 6,100,100 for reasons stated on pages 7-8 of the Office Action (Paper No. 031804). In support of this rejection, the Examiner asserts that Nagano '100 discloses a method of washing the etched layer while etching, and

Appl. No. 10/090,761
Amendment dated June 24, 2004
Reply to Office Action of March 24, 2004

that Yokohama '984 discloses a method of removing the deposition of the side wall by the washing after the etching of Pt, such that Applicants' claims 13 and 15 would be obvious over Yokohama '984 and Nagano '100.

As previously discussed, Applicants' base claim 13 defines features, as shown in FIGs. 14-17, and Applicants' claim 15 defines features shown in FIGs. 16-17. Specifically, Applicants' base claim 13 has been amended to define a method of fabricating a semiconductor device using at least one layer of hardly-etched material formed on a substrate, and a mask formed on said hardly-etched film, said method comprising the steps of:

performing a first etching of said layer of hardly-etched material by a predetermined amount using said mask, during which a first part of said layer exposed for the first time by said first etching is formed with a first taper angle θ with respect to a surface of said substrate; washing out an etching product in the middle of the etching; and performing a second etching of said layer of hardly-etched material by a remaining amount using said mask, during which a second part of said layer exposed for the first time by said second etching is formed with a second taper angle of substantially Φ with respect to the surface of said substrate given by $\tan \Phi = (re-rd) / ((rd-re \times \cos\theta) \times \sin\theta)$, wherein the second taper angle is larger than the first taper angle, and wherein re is an etching rate of said film of hardly-etched material and rd is a deposition rate of reaction product to said side wall.

These features of Applicants' base claim 13 are not disclosed or suggested anywhere in Yokoyama '984 and Nagano '100. As a result, Applicants believe that the rejection of Applicants' claims 13 and 15 be withdrawn, and that claims 13 and 15 be placed in condition for allowance because neither Yokohama '984 nor Nagano '100 discloses or suggests such a technical concept that the material to be etched is washed on the way of the etching process and thereafter etched again thereby to

Appl. No. 10/090,761
Amendment dated June 24, 2004
Reply to Office Action of March 24, 2004

increase the tapered angle of the side wall of the material to be etched, as defined generally in Applicants' base claim 13.

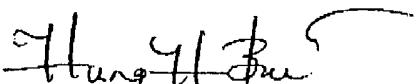
In view of the foregoing amendments, arguments and remarks, all claims are deemed to be allowable and this application is believed to be in condition to be passed to issue. Should any questions remain unresolved, the Examiner is requested to telephone Applicants' attorney at the Washington DC area office at (703) 312-6600.

To the extent necessary, Applicants petition for an extension of time under 37 CFR §1.136. Please charge any shortage of fees due in connection with the filing of this paper, including extension of time fees, to the Deposit Account of Antonelli, Terry, Stout & Kraus, No. 01-2135 (Application No. 500.41317X00), and please credit any excess fees to said deposit account.

Respectfully submitted,

ANTONELLI, TERRY, STOUT & KRAUS, LLP

By


Hung H. Bui (Reg. No. 40,415)

Attorney for Applicant(s)

HHB:btd

1300 North Seventeenth Street, Suite 1800
Arlington, Virginia 22209
Tel.: (703) 312-6600
Fax: (703) 312-6666